FINAL TECHNICAL REPORT

Office of Naval Research Contract Number: N00014-88-K-0084

"Chaotic and Bifurcating Nonlinear Systems Driven by Noise with Applications to Laser Dynamics."

1 December 1987 through 31 October 1989

No Fund Extension: 1 November 1989 through 31 March 1990

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I. Summary of Work Accomplished

One aspect of the research work was focused on the effects of noise as a driving force in various nonlinear dynamical systems. Effects studied were postponements of bifurcations[1,12], state dependent diffusion[2], a mean first passage time in a system with both random temporal forcing in a random potential[3], a mean first passage time problem with colored noise[4].

A second aspect involved studies on switching properties of nonlinear systems in the presence of noise[5], and a special application of the results to a noise quenched, correlated, spontaneous emission laser[7].

A third major effort was devoted to studies on stochastic resonance (SR), with a remark on the theory[8], a long work on the use of analog simulations in studies of SR[9,11], a study on order and disorder in SR[10].

At this point, a study was done on noise induced topological transitions in the two-dimensional stationary probability density of an archetypal bistable system[13].

Finally, a new quantity was introduced to general studies on SR: the escape time probability distribution, wherein the theory, digital and analog simulations were accomplished[14]. These new studies hold great promise for applications in a number of fields, including the creation of a deeper understanding of how noise assisted information is transmitted in biological neurons.

The superscripted citation numbers above refer to the Index of Publications listed in III below.

II. Index of Technical Reports

No technical reports were published during this period.

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III. Index of Publications

The following is a list of scientific papers published with support from this contract. This technical report is comprised of all papers cited below.

1. "Swept parameter induced postponements and noise on the Hopf bifurcation," Phys. Rev. A. **36** 1492 (1987) (with Fronzoni and McClintock).

2. "Analog simulation of a simple system with state dependent diffusion," J. Stat. Phys. **54**, 1411 (1989) (with K. Sinha)

3. "Mean First Passage Time in Random Fields", Phys. Rev. A **38** 571 (1988) Rapid Communications (with A. Engel)

4. Comment on First Passage Time Calculations for Colored Noise Driven Bistable Systems," Phys. Lett. A. **131**, 322 (1988) (with F. Marchesoni)

5. "Switching in the Presence of Noise: The Decay of an Unstable State," Phys. Rev. A **38**, 4690 (1988) (with M. James, P. Hanggi and C. Van der Broeck)

6. "Giorgio Careri: The Early Years and the Birth of Low Temperature Physics in Italy", invited biographical sketch, J. Molec. Liquids, **41**, 1 (1989) Special Issue in Honor of G. Careri.

7. "Noise Quenching in the Correlated Spontaneous-Emission Laser as a Multiplicative Noise Process: The Role of Colored Noise", Phys. Rev. A **41**, 3950 (1990) (with James, Habiger, Risken and Schleich).

8. "Remark on Stochastic Resonance", Phys. Rev. A **39**, 4323 (1989) (with Debnath and Zhou)

9. "The Use of Analog Simulation in Studies on Noise Driven Nonlinear Dynamical Systems", Invited Review, Proceedings of the 10th Intern. Conference on Noise in Physical Systems, Budapest, Hungary August 1989 (Akademiai Kiado, Budapest 1990)

10. "Stochastic Resonance: How Increasing the Noise Can Result in More Order", Proceedings of the 10th Intern. Conference on Noise in Physical Systems, Budapest, Hungary, August 1989 (Akademiai Kiado, Budapest 1990)

11. "Analog Simulations of Stochastic Resonance", Phys. Rev. A **41**, 4255 (1990) (with Zhou)

12. "The influence of colored noise on Hopf-bifurcating systems", in *Irreversible Processes and Selforganization*, Teubner-Texte zur Physik, band 23, edited by W. Ebeling and H. Ulbricht, Teubner-Verlag, Leipzig, 1989 (with Schmera and Schimansky-Geier).

13. "Holes in the two-dimensional probability density of strongly colored noise driven bistable systems" Phys. Rev. A 42, 703 (1990) (with Debnath, Leiber, Risken and Marchesoni)

14. "Escape time distributions of a periodically modulated bistable system with noise" Phys. Rev. A, 42, 3161, 1990 (with Zhou and Jung)

REPORT OF INVENTIONS AND SUBCONTRACTS

(Pursuant to "Patent Rights" Contract Clause) (See Instructions on Reverse Side.)

FORM APPROVED OMB NO. 0704-0016

1a. NAME OF CONTRACTOR SUBCONTRACTOR	c. CONTRACT NUMBER	2a. NAME OF GOVERNMENT PRIME CONTRACTOR	c. CONTRACT NUMBER	3. TYPE OF REPORT (check one)
Univ. of Mo.	N00014-88-K-0084	~~U.S. Navy~~		☐ INTERIM ☒ FINAL
b. ADDRESS (include Zip Code) Dept. of Physics UMSL St. Louis, MO. 63121	d. AWARD DATE (YYMMDD)	b. ADDRESS (include Zip Code)	d. AWARD DATE (YYMMDD)	4. REPORTING PERIOD (YYMMDD) FROM 1 Dec 1987 TO 31 MARCH 1990

SECTION I - SUBJECT INVENTIONS

5. "SUBJECT INVENTIONS" REQUIRED TO BE REPORTED BY CONTRACTOR/SUBCONTRACTOR *(If "None", so state)*

a. NAME OF INVENTOR(S) (Last, First, M.I.)	b. TITLE OF INVENTION(S)	c. DISCLOSURE NO., PATENT APPLICATION SERIAL NO. OR PATENT NO.	d. ELECTION TO FILE PATENT APPLICATIONS				e. CONFIRMATORY INSTRUMENT OR ASSIGNMENT FORWARDED TO CONTRACTING OFFICER	
			UNITED STATES		FOREIGN			
			YES	NO	YES	NO	YES	NO
No inventions								

f. EMPLOYER OF INVENTOR(S) NOT EMPLOYED BY CONTRACTOR/SUBCONTRACTOR.		g. ELECTED FOREIGN COUNTRIES IN WHICH A PATENT APPLICATION WILL BE FILED.	
i. NAME OF INVENTOR (Last, First, M.I.)	i. NAME OF INVENTOR (Last, First, M.I.)	i. TITLE OF INVENTION	ii. FOREIGN COUNTRIES OF PATENT APPLICATION
ii. NAME OF EMPLOYER	ii. NAME OF EMPLOYER		
iii. ADDRESS OF EMPLOYER (include Zip Code)	iii. ADDRESS OF EMPLOYER (include Zip Code)		

SECTION II – SUBCONTRACTS *(Containing a "Patent Rights" clause)*

6. SUBCONTRACTS AWARDED BY CONTRACTOR/SUBCONTRACTOR *(If "None", so state)*

a. NAME OF SUBCONTRACTOR(S)	b. ADDRESS (include Zip Code)	c. SUBCONTRACT NO.(S)	d. DAR "PATENT RIGHTS"		e. DESCRIPTION OF WORK TO BE PERFORMED UNDER SUBCONTRACT(S)	f. SUBCONTRACT DATES (YYMMDD)	
			CLAUSE NO.	DATE (YYMM)		AWARD	ESTIMATED COMPLETION
No subcontracts							

SECTION III – CERTIFICATION

7. CERTIFICATION OF REPORT BY CONTRACTOR/SUBCONTRACTOR *(Not required if [ ] Small Business or [ ] Non Profit organization. Check appropriate box.)*

a. NAME OF AUTHORIZED CONTRACTOR/SUBCONTRACTOR OFFICIAL (Last, First, M.I.) Moss, Frank E

b. TITLE Professor of Physics

c. I certify that the reporting party has procedures for prompt identification and timely disclosure of "Subject Inventions," that such procedures have been followed and that all "Subject Inventions" have been reported.

SIGNATURE OF AUTHORIZED CONTRACTOR/SUBCONTRACTOR OFFICIAL

DATE (YYMMDD) 91MAR22

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S/N 0102-LF-000-8821

EDITION OF 1 OCT 75 IS OBSOLETE